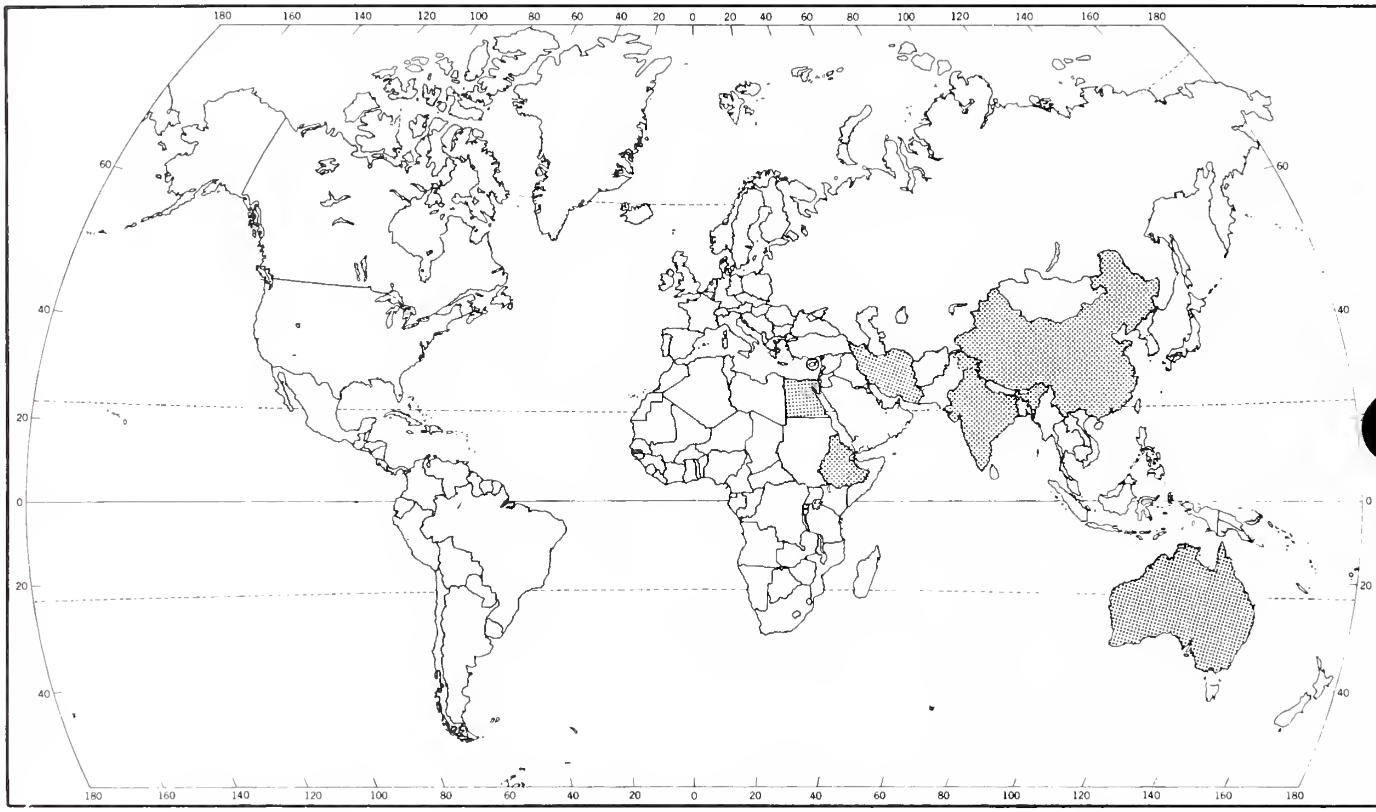
PESTS NOT KNOWN TO OCCUR IN THE UNITED STATES OR OF LIMITED DISTRIBUTION, NO. 53: WHEAT YELLOW SLIME

Prepared by A. Green, Biological Assessment Support Staff, PPQ, APHIS, USDA, Federal Building Room 634, Hyattsville, MD 20782

Disease	WHEAT YELLOW SLIME
Pathogen	*Clavibacter tritici* (Carlson and Vidaver) Davis et al.
Selected Synonyms	*Corynebacterium tritici* (Hutchinson) Burkholder *Corynebacterium michiganese* pv. *tritici* (Hutchinson) Dye and Kemp *Pseudomonas tritici* (Hutchinson) Burkholder Tundu disease, spike blight, yellow ear rot disease
Class: Order: Family	Schizomycetes: Eubacteriales: Corynebacteriaceae
Economic Importance	Wheat heads infected with yellow slime disease often do not yield any grain. In India, the disease has caused an estimated 1-2 percent loss in the total yield with individual fields losing as much as 50 percent (Vasudeva and Hingorani 1952).
Hosts	*Triticum aestivum* (bread wheat), *T. durum* (durum wheat), *T. dicoccon* (emmer), and *T. pyramidale*.
General Distribution	*Clavibacter tritici* is reported from Australia, China, Cyprus, Egypt, Ethiopia, India, and Iran (Commonwealth Mycological Institute 1978).
Characters	Pure cultures of *C. tritici* can easily be isolated from diseased wheat specimens using dilution plating. Yeast-glucose-chalk-agar is an artificial medium that supports good growth of the bacterium. Resulting colonies are convex, bright yellow, glistening, and moist in appearance. They turn orange with age (Swarup and Gupta 1971). Bacteria gram positive, aerobic, rod shaped, 0.5-0.8 X 0.95-1.3 µm, and nonmotile. Optimal growth at 23-25° C with temperature maximum of 34° C. Acid produced from mannose, liquifies gelatin and utilizes acetate (Carlson and Vidaver 1982, Swarup and Gupta 1971, Breed, Murray, and others 1957).

Clavibacter rathayi (Carlson and Vidaver) Davis et al. also causes a yellow slime disease in certain grasses. *C. rathayi* produces no acid from mannose, does not liquify gelatin and does not utilize acetate. *C. rathayi* and *C. tritici* differ in the patterns produced by polyacrylamide gel electrophoresis of their cellular proteins (Davis, Gillaspie, and others 1984, Carlson and Vidaver 1982, Bradbury 1973a).



Clavibacter tritici distribution map prepared by Non-Regional Administrative Operations Office and Biological Assessment Support Staff, PPQ, APHIS, USDA

Characteristic Damage

Wheat yellow slime is very destructive to the infected plant. Leaves, stems, spikes, and grain are all affected. The first symptoms observed in the field are parallel yellow or white streaks following the veins or midrib of infected wheat leaves (Gupta and Swarup 1972). The characteristic sign of this disease is the bright yellow gummy ooze exuded on the leaf surfaces of young plants, on aborted spikes, and on leaves in

contact with those spikes. In humid weather, this yellow slime (which is a mass of bacteria) trickles down forming sticky layers on the plant parts. In dry, hot weather, the exudate becomes brittle and hard.

Infected culms sometimes die in early stages of their development. Other times, a short narrow spike emerges which is curled and distorted (Fig. 1), its grain partially replaced by the bacterial mass. In severe infections, the spikelets are so badly deformed that no grain develops. The stem will also be distorted when the spike shows bacterial symptoms (Gupta and Swarup 1968, Suryanarayana and Mukhopadhaya 1971).

(Fig. 1)

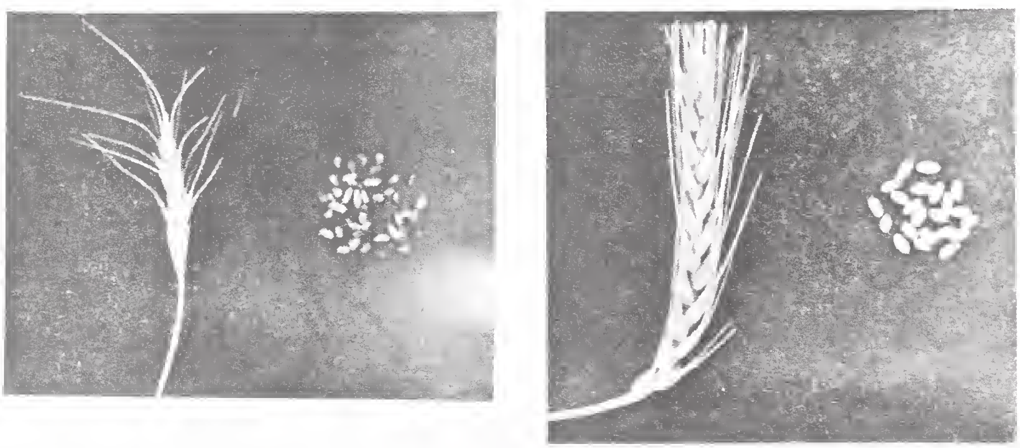
Clavibacter tritici infection of wheat showing distortion of spikes (From Sabet 1954).

The nematode Anguina tritici (Steinbuch) Chitwood is a necessary vector for the bacterial pathogen Clavibacter tritici. Yellow slime disease does not develop in the absence of A. tritici (Gupta and Swarup 1972).

This nematode is also pathogenic, causing earcockle disease of wheat. Wheat leaves of nematode-infected plants are twisted, wrinkled, and curled. Stems and spikes are also distorted (Fig. 2). Galls, which are modified kernels containing numerous nematode larvae, replace all or some of the grain. The galls superficially resemble normal kernels but are hard and dark brown to black (Suryanarayana and Mukhopadhaya 1971). Earcockle disease is found throughout the wheat-growing areas of the world, and reportedly in the United States.

Clavibacter rathayi (Carlson and Vidaver) Davis et al. causes a yellow slime disease of certain grasses. This pathogen infects Triticum aestivum (bread wheat) when artificially inoculated along with nematode vectors. C. rathayi is not considered a pathogen of wheat, however, under natural conditions. The natural hosts of C. rathayi are Dactylis glomerata (cocksfoot, orchardgrass), Cynodon dactylon (bermudagrass), and Secale cereale (rye). Single reports of presumed C. rathayi infections in Virginia and Oregon in the 1920's cannot be verified. No cultures were preserved. C. rathayi like C. tritici is only known to be namatode transmitted (Bradbury 1973a, Vidaver, personal communication 1984).

(Fig. 2)



Anguina tritici: Left - nematode damaged wheat spike with galls. Right - healthy wheat spike and grain (Courtesy D. Suryanarayana and M. C Mukhopadhyana, Indian Journal of Agricultural Science, Indian Council of Agricultural Research; 1971).

Detection Notes

1. All countries with yellow slime of wheat (except Ethiopia) also have flag smut, *Urocystis agropyri* (Preuss) Schroet. All wheat plants, seeds, and plant parts from these countries are, therefore, prohibited entry under Title 7, Part 319.59 of the Code of Federal Regulations (except with departmental permit).

2. Look for wheat seed samples contaminated with nematode seed galls. These galls can harbor the bacterium *C. tritici* and offer this pathogen a means of entry into the United States.

3. In the field, look for bright yellow exudate on the above ground parts of infected wheat plants. In hot, dry weather, this slime will harden.

4. Search for curled and distorted emerging heads. Grain is either partially or totally absent.

5. Positive identification of *C. tritici* can only be made through examination of bacterial cultures isolated from infected plants. Submit the seed, nematode galls, or dried, pressed leaves from wheat plants showing suspect symptoms.

Biology and Etiology

Clavibacter tritici has an obligate etiological relationship with the seed gall nematode, *Anguina tritici*, in the development of yellow slime of wheat. The nematode vectors the bacteria to the meristem of the wheat seedling. The nematode is believed necessary to incite the bacterial infection. Mechanical introduction of the bacterium into the apical meristem does not produce disease symptoms (Suryanarayana and Mukhopadhaya 1971).

Wheat plants did not develop symptoms of yellow slime disease if inoculated with either surface-sterilized larvae of the nematode *A. tritici* or with solutions of *C. tritici*. Disease symptoms did develop, however, if the plants were treated with an inoculum containing both nematodes and the bacteria. Likewise, inoculum with either the unsterilized nematode larvae or crushed wheat galls taken from areas infected with yellow slime disease was found to induce that disease. The bacteria do not appear to be carried internally by the nematode but on the outer surface of the larvae or in the galls. The presence of both organisms is necessary for successful disease development (Gupta and Swarup 1972, Swarup and Singh 1962).

The nematode seed galls appear to provide a favorable environment for the perpetuation of the bacteria between crop seasons. While survival in the soil rarely exceeds 7 months (Suryanarayana and Mukhopadhaya 1971), the bacteria have

remained viable for at least 5 years within seed galls (Bradbury 1973b). The galls also provide a means of long distance dispersal as they are a frequent contaminant of healthy wheat seed.

A. tritici has long been known to cause earcockle disease of wheat. Second stage larvae of the nematode emerge from the galls produced in the previous crop season. They attack the growing points of emerging wheat plants, feeding ectoparasitically. When the nematodes reach the embryonic floral primordia, they begin their endoparasitic phase. The galls then form from the interaction of floral tissue and the infecting nematodes. These galls replace the healthy wheat kernels. Within the galls, the nematodes mature to the adult stage and lay their eggs. From the eggs come the larvae which will remain in the gall until the next crop season.

Bacterial masses produced in the yellow slime disease contaminate the seed galls, plant debris, and soil. It is from these sources that nematode larvae pick up inoculum for infection.

Yellow slime of wheat has been observed to be more severe in areas of poor drainage. Disease severity increased significantly in fields which were intentionally flooded (Vasudeva and Hingorani 1952).

Temperature affected bacterial growth on artificial media. Growth was observed at 8-35° C with an optimal range of 25-30° C. Cultures exposed to 45° C did not revive, indicating the sensitivity of the bacterium to high temperatures (Swarup and Gupta 1971).

Control

Controlling the seed gall nematode is the most effective way of controlling wheat yellow slime. Use of clean seed, free of galls, prevents dissemination of the nematode. Mechanical seed separators with sieves of differing pore size are often used to separate the galls from wheat seed.

In brine flotation, the wheat seed is placed in a 20 percent brine solution. From differences in specific gravity, the seed sinks and the galls float, allowing the latter to be easily skimmed off. The seeds are then removed, washed, and dried (Suryanarayana and Mukhopadhaya 1971).

In another treatment, infested seed is soaked in hot water at 54° C for 10 minutes. This method will usually kill the nematodes without damaging the seed. It has an added benefit of killing the spores of Ustilago tritici (Pers.) Rostr., causal agent of loose smut, if this pathogen is present.

One cultural control, planting wheat in fields with good drainage and minimal flooding reduces disease severity.

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